Erkundung von Softwarelandschaften mithilfe von HCI in ExplorViz

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1. Motivation

2. Foundations

3. Design

4. Implementation

5. Evaluation

6. Conclusions
Motivation

- to gain knowledge about a new kind of interface
- to explore new ways of task comprehension and user experience
- to test, if a user would accept this kind of user experience
Foundations
the Electroencephalography (EEG) is based on the works of Hans Berger from the year 1924

the brain works through electricity and biochemical processes[1, 2, 3]

EEG signal represents the voltage of the brain [3, 2]

EEG signals represent ones mental state (sleeping, concentrating)
a neuro-technical interface [6]
based on EEG, fMRI or NIRS
can convert brain signals into computer signals
Emotiv Insight¹
- made from the company *Emotiv Systems*
- 5 EEG sensors and two reference sensors
- use of Community SDK² and Java 1.6
- no insight into device‘s working processes
- user has to adapt to the device
- writes into query
- only one request per time to device, else crash

¹https://emotiv.com/insight.php:
²https://github.com/Emotiv/community-sdk
Design
Design of the Software

goal: implementation of BCI in ExplorViz to navigate through landscape

▶ we have to implement Java-code into the browser
▶ our solution divides our software in a browser-internal as Ember.js plugin and -external part as Java-program
  ▶ sustainable
  ▶ browser not naturally able to use multi-threading
  ▶ performance is a critical point
▶ communication by WebSocket connection
Design of the Software

WebSocket Connection

**Abbildung: WebSocket Connection**

**Design**

- **Java-program**
- **Emotiv Insight**
- **Ember.js plugin**

**WebSocket connection**

**TCP**
we want to implement our mental commands with best possible distinction
relaxation and concentration => better distinction
functionalities: zoom in and zoom out
limited meaningful functionalities in 2D visualization
BCI-mode
Implementation
Implementation

- browser-external part written as standalone application in Java 1.6
- browser-internal part realized as Ember.js plugin
- WebSocket connection implemented with usage of libraries
- influenced by VR project
  - controller to trigger BCI-mode
  - rotation and lifting/lowering as functionalities
Implementation of our Browser-External Part

Implementation of the EmotivGUI

EmotivController

AbstractEmotiv

MentalCommand

TrainingInit

AbstractEmoState

UpdatedDecorator

EmotivInit

EmotivThread

EmotivDevice

WebSocketDecorator

WebSocketServerSingleton

WebSocketServer

instance: WebSocketServerSingleton

- Abbildung: MVC pattern implementation

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Implementation of our Browser-Internal Part

- Ember.js plugin
- service managing WebSocket connection
- Blackbox-problem solved by Eventlisteners with only use of JavaScript

```javascript
triggerMentalCommand(mentalCommand) {
    let canvas = $$('#threeCanvas')[0];
    let event = new Event('bciaction', {
        'bubbles': true,
        'cancelable': false
    });
    canvas.dispatchEvent(event);
}
```
Evaluation
Evaluation

▶ research question: *Will a user accept our implementation in the context of VR*

▶ hypothesis:
  - h1: The user accepts the integration of the BCI into our VR room
  - h2: The user accepts the controller as additional tool
  - h3: The user is able to trigger at least one mental command to his/her satisfaction
- qualitative study in collaboration with VR bachelor thesis
- as additional tool a survey
- we take the ExplorViz demo-landscape\(^3\) visualized in VR room with closed systems
- only geometric tasks

\(^3\)http://samoa.informatik.uni-kiel.de:8181/
Evaluation

Design of our operational Structure

Evaluation

- information paper
- survey regarding general questions
- VR part
- BCI part
  1. short introduction
  2. setup BCI + VR
  3. training phase: training of 3 mental commands (3 training sessions each)
  4. short introduction in controller functionality/BCI-mode
  5. 4 simple tasks
  6. final survey
parts inspired by hypothesis

**h1**: user’s evaluation in term of VR + BCI

**h2**: user’s evaluation in term of controller usage

**h3**: user’s evaluation in term of mental commands
10 participants
broken sensor tips => loss of two participants
the setup of our device very different
training phase very individual
Evaluation
Results of h1: user’s evaluation in term of VR + BCI

<table>
<thead>
<tr>
<th>Ø</th>
<th>σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfortable to wear</td>
<td>1</td>
</tr>
<tr>
<td>VR was disturbing</td>
<td>2</td>
</tr>
<tr>
<td>Would use BCI again</td>
<td>3</td>
</tr>
<tr>
<td>Would use BCI+VR again</td>
<td>4</td>
</tr>
</tbody>
</table>

Degree of agreement

- Comfortable to wear
- VR was disturbing
- Would use BCI again
- Would use BCI+VR again
## Evaluation

Results of h2: user’s evaluation in term of controller usage

<table>
<thead>
<tr>
<th>Controller</th>
<th>One thought for lift/drop</th>
</tr>
</thead>
<tbody>
<tr>
<td>disturbing</td>
<td>adequate</td>
</tr>
<tr>
<td>supportive</td>
<td></td>
</tr>
</tbody>
</table>

**Degree of agreement**

- Controller were disturbing
- Controller were supportive
- One thought for lift/drop adequate

### Graph

- **Axes**:
  - Y-axis: Degree of agreement
  - X-axis: 
    - \( \emptyset \)
    - \( \sigma \)

### Legend

- Controller were disturbing
- Controller were supportive
- One thought for lift/drop adequate

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Evaluation

Results of h3: user’s evaluation in term of mental commands

<table>
<thead>
<tr>
<th>Ø</th>
<th>σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good Discrimination between mental commands</td>
<td>Easy to lift/lower</td>
</tr>
<tr>
<td></td>
<td>Concentration for lift-/lowering was senseful</td>
</tr>
<tr>
<td>Easy to rotate</td>
<td>Relaxation for rotation was senseful</td>
</tr>
</tbody>
</table>

Degree of agreement
h1: user would use BCI and VR again despite of low comfort => yes

h2: user mostly described controller not as disturbing but supportive and accepted using of controller for two mental commands => yes
Threats of Validity

- training always different
- environment
- VR part exhausted
- broken sensor tips
- bad evaluation of mental commands
Conclusions
Conclusions

- browser-external part for processing necessary
- long-term studies could be needed
- adequate results in controlling the device with only 80 seconds training
- our tool should provide more possibilities for individualization
- future work:
  - individualization => configuration of MC
  - long-term studies regarding regular training sessions
  - Better user GUI
Literature


Christian Fichter. „Brain-Computer Interfaces“. In: (2002).


